FMVSS AND CMVSS 105 HYDRAULIC BRAKE COMPLIANCE GUIDELINES FOR ALTERED RANGER VEHICLES AND ECONOLINE VEHICLES (EXCEPT WHEN COMPLETED AS A SCHOOL BUS)

105 INFORMATION

Vehicle weights and dimensional information required for center of gravity calculations are available in the Source Book. See you local Ford Dealer and refer to appropriate model year and specific vehicle for required information.

Abbreviation definitions and a vehicle diagram which are required for the equations in the FMVSS 105 segment of this document are shown on the next page.

The vehicle, as altered will conform to FMVSS and CMVSS No. 105, Hydraulic Brake system, provided that:

- No alterations, modifications, or replacements are made to the service brake system, anti-lock brake system, the vacuum system, the parking brake system, wheels or tires, the brake system indicator lamp and wiring, the brake system reservoir labeling, the suspension ride height or spring rates.
- Any other components removed are replaced by items with the same weight distribution (i.e., seat replacements).
- The vertical distance from the ground to the completed vehicle center of gravity should not exceed 36 inches for vehicles <8000 lb GVWR and 48 inches for vehicles $\geq$ 8000 lb GVWR. (Restrictions for other standards may also apply).
- For Ranger Pickup Box Removal, the SUB weights found in table A page 195 are met, as is the maximum Unloaded Vehicle Weight.
- The applicable GAWR's, GVWR and accessory reserve capacity (ARC) weights (See preceding pages) are not exceeded.
- The applicable center of gravity limitations are met using one of the following calculation methods:

FOR VEHICLES UNDER 3629 KG (8000 LB) GVWR

- The rear weight component (W_{rul}), as measured between the rear tires and the ground, does not exceed 58% of the completed vehicle weight at Unloaded Vehicle Weight plus 400 lb located in the driver and front passenger area (W_{ul}).

  Maximum W_{rul} = .58 x W_{ul} (see definitions on the next page).

  For additional information, see Table C on this page for E-150 & E-250 with RV Prep Package. Econoline vehicles equipped with RV Prep Package must have an Unloaded Vehicle Weight within the weight percentages listed in the following table.
- The horizontal center of gravity of the SUB† is rearward of L_{MIN}†† for the appropriate vehicle description in the chart below.

  L_{MIN} does not apply to a SUB of 120 lb or less when installed rearward of the front seats and forward of the centerline of the rear axle (Do not restrict seat travel).

TABLE A
HORIZONTAL CENTER OF GRAVITY FORWARD LIMIT

Vehicle	Wheelbase Millimeter (inch)	L min Millimeter (inch)
E-150	3505 (138)	1473 (58)
E-250	3505 (138)	1524 (60)

TABLE B
ECONOLINE PASSENGER LOAD

GVWR (lb)	P (lb)
8,000 – 10,000	400
10,001 – 15,000	500

The horizontal center of gravity for the SUB is:

- At or forward of the rear axle centerline. The vertical center of gravity for the completed vehicle at Unloaded Vehicle Weight + 400 lb front seat passenger load (CG_V – Equation A) must not exceed 36 inches, when measured from the ground.
- Behind the rear axle centerline. The vertical center of gravity of the completed vehicle at Unloaded Vehicle Weight + 400 lb passenger load must fall within the appropriate range determined from Table 1, page 48. The value of CG_h (Equation B), which approximates the horizontal center of gravity of the completed vehicle, is used in Table 1 to determine the vertical center of gravity limits for the completed vehicle. The value CG_v (Equation A), which approximates the vertical center of gravity of the completed vehicle, must fall within the appropriate range determined from Table 1.

EQUATION A:

$$CG_v = \frac{CG_{vb}W_b + CG_{vc}W_c + 10,000}{W_t}$$

EQUATION B:

$$CG_h = \left(\frac{W_{rb} + W_{rc} + \left(\frac{400 \times CG_{hp}}{WB}\right)}{W_t}\right) X\ WB$$

FOR VEHICLES 3629 KG [8000 LB] THROUGH 6804 KG (15,000 LB) GVWR

The horizontal center of gravity for the SUB is:

- At or forward of the rear axle centerline. The vertical center of gravity for the completed vehicle at GVWR (CG_v – Equation C) must not exceed 48 inches, when measured from the ground.
- E-250/350 Stripped Chassis, E250 Cutaway, E350 Super Duty Cutaway (DRW) and E450 Super Duty Cutaway must have a horizontal CG for the second unit body at or forward of the centerline of the rear axle.
- Behind the rear axle centerline. The vertical center of gravity for the completed vehicle at GVWR must fall within the appropriate range determined from Table 2 page 25. The value of CG_h (Equation D), which approximates the horizontal center of gravity of the completed vehicle, is used in Table 2 to determine the vertical center of gravity limits for the completed vehicle.

EQUATION C: $$CG_v = \frac{CG_{vb}W_b + CG_{vc}(W_c + W_l) + 25P}{GVWR}$$

EQUATION D: $$CG_h = \left(\frac{W_{rb} + W_{rc} + \left(\frac{P\ X\ CG_{hp}}{WB}\right) + W_{rl}}{GVWR}\right) X\ WB$$

TABLE C
FMVSS 105 Unloaded Vehicle Weight variable for Econoline vehicles with a GVWR less than 3629kg (8000 lb)

This procedure requires that both the %**FLL** and %**FV** (weight percentages calculated in item 7) are between 44% and 57% for E-150 van and between 40% and 60% for E-250 van.

Prior to utilizing the formulas below, the completed vehicle must be weighed with all the fluids at capacity (including a full tank of fuel). Obtain the front component weight (weight between both front tires and the ground), the rear weight component (weight between both rear tires and the ground), and the total vehicle weight.

1. **FLL** (Front Lightly Loaded weight) = Front Weight Component + 259 lb	6. To determine the factor **FV** (Front Variable) use the following:
2. **RLL** (Rear Lightly Loaded weight) = Rear Weight Component + 141 lb	• If **FLL** is greater than **FP,** then **FV** = **FLL** • If **RLL** is greater than **RP,** then **FV** = **GVWR** – **RLL** • If **FLL** is less than or equal to **FP** and **RLL** is less than or equal to **RP,** then **FV** = **FP**
3. **TLL** (Total Lightly Loaded weight) = Total Vehicle Weight + 400 lb	
4. **FP** (Front Proportional weight) = $\frac{GVWR\ X\ Front\ GAWR}{(Front\ GAWR\ +\ Rear\ GAWR)}$	7. Calculate the weight percentage as follows: • % **FLL** = $\frac{FLL}{TLL}$ **X 100** • % **FV** = $\frac{FV}{GVWR}$ **X 100**
5. **RP** (Rear Proportional weight) = GVWR – **FP**	

† *SUB – Second Unit body (See definition next page.)*

†† L_{min} *=the minimum horizontal center of gravity of the SUB measured in inches rearward from the centerline of the front axle.*

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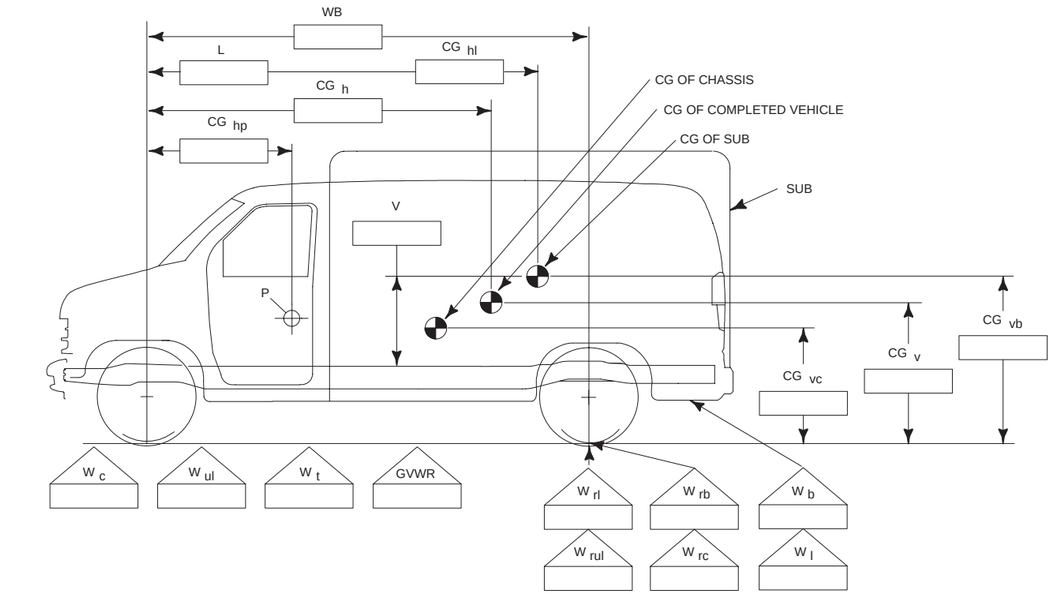
V* = Vertical Center of Gravity of Sub in inches above top of frame at cab back panel for chassis cab vehicles or top of cargo floor for Incomplete Van vehicles.

L* = Horizontal distance in inches between the SUB center of gravity and the ℄ of the front axle.

W_{ul}* = Unloaded vehicle weight (pounds) consisting of the curb with SUB plus 400 lb located in the front driver/passenger location.

W_{rul}* = Rear weight component of the unloaded vehicle weight (pounds) W_{ul}.

P = Passenger load (See Table B page 45).



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CG_v = Vertical distance from the ground to the center of gravity (inches) of the completed vehicle.

CG_h = Horizontal distance from ℄ of the front wheels to completed vehicle center of gravity (inches).

CG_{vb} = Vertical distance from the ground to the center of gravity of the SUB and/or permanently attached added equipment (inches). (See the Calculation Suggestions on Page 47.)

CG_{vc} = Vertical distance from the ground to the center of gravity of the chassis (inches) (including cab if original equipment). (Taken from Table 2, Page 48.)

CG_{hp} = Horizontal distance form the ℄ of the front wheels to the P (passenger weight) (taken from Table 3 page 48.)

W_b = Weight of the SUB and/or permanently attached added equipment (pounds).

W_{rb} = Weight at the rear wheels of the SUB and/or permanently attached added equipment (pounds).

W_{rc} = Weight of the rear wheels of the vehicle (chassis and cab) (fuel tanks full) (pounds). Including option weight.

W_c = Weight of the vehicle (chassis and cab) (fuel tanks full) (pounds). Including option weight.

WB = Vehicle wheelbase (inches).

W_t = Total unladen weight = (W_b + W_c + P)

GVWR = Gross Vehicle Weight Rating of the vehicle (pounds).

W_l** = Remaining cargo capacity (pounds).
Where : W_l = GVWR – (W_b + W_c + P)

W_{rl}** = Weight of the remaining cargo capacity on the rear wheels (pounds).

$$W_{rl} = \frac{(CG_{hl})W_l}{WB}$$

CG_{hl}** = Horizontal distance from the ℄ of the front wheels to the cargo center of gravity (inches). (Taken from Table 3, Page 48) for many common vehicles. If the CG_{hl} is not given in the table, then it may be estimated as the distance from the ℄ of the front wheel to the horizontal midpoint of the cargo area.

SUB = A Second Unit Body consists of the body structure and/or all the cargo carrying, work performing and/or load bearing components and/or equipment installed by a subsequent stage manufacturer on an incomplete vehicle, such that the incomplete vehicle becomes a completed vehicle.

* Required for < 8000 lb. GVWR calculations only.

** Required for ≥ 8000 lb. GVWR calculations only.

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SECOND UNIT BODY CENTER OF GRAVITY CALCULATION SUGGESTIONS

In the case where the rear weight of the SUB and/or added equipment must be reduced and the CG_V is found to be below the allowed minimum CG_V it may be possible to bring the vehicles into comnpliance by moving the CG_h forward. Forward movement of the CG_h can be accomplished by:

- Redistributing the weight of the SUB and/or added equipment.
- Adding **permanently** attached ballast forward of the $CG_{h.}$ In order to reduce the rear weight, the ballast must be forward of the front axle. (Caution must be taken not to exceed the GVWR of front GAWR of the vehicle.)

The following general equations can be used to find the center gravity of the SUB and/or added equipment when there are several elements making up the CG.

NOTE: Removal of the components/body parts would be represented by a negative weight being used in these calculations.

$$CG_{vb} = \frac{CG_{vb1}\ (W_{b1}\ ) + CG_{vb2}\ (W_{b2}\ ) + ... + CG_{vbn}\ (W_{bn}\ )}{W_{b1}\ + W_{b2}\ + ...W_{bn}}$$

and the horizontal CG location of the combined SUB and added equipment is:

$$CG_{hb} = \frac{(W_{rb1}\ + W_{rb2}\ + ... + W_{rbn}\ )WB}{W_{b1}\ + W_2\ + ... + W_{bn}}$$

The front/rear weight break down can be found with the use of the following equation:

$$W_{rb} = \frac{CG_{hb}\ (W_{b1}\ + W_{b2} + ... + W_{bn}\ )}{WB}$$

Conversely, the front weight component of the SUB and added equipment is:

$$W_{fb}\ = (W_{b1}\ + W_{b2}\ + ... + W_{bn}\ ) - W_{rb}$$

SAMPLE CALCULATIONS

Vehicles <8000 lb GVWR

Sample (1) Ranger (4x2) pickup box removal vehicle 118 inch WB 4800 lb GVWR

Known : W_b = 250 lb W_{rb} = 260 lb (behind rear axle)
W_c = 2912 lb; W_{rc} = 1080 lb
CG_{vb} = 28 CG_{vc} = 25.5 CG_{hp} = 53.9
This vehicle falls in the under 8000 lb GVWR category and the SUB CG is behind the rear axle.

From equation A & B.

$$CG_v = \frac{(28)(250) + (25.5)(2912) + 10000}{3562} = 25.6 \text{ inches}$$

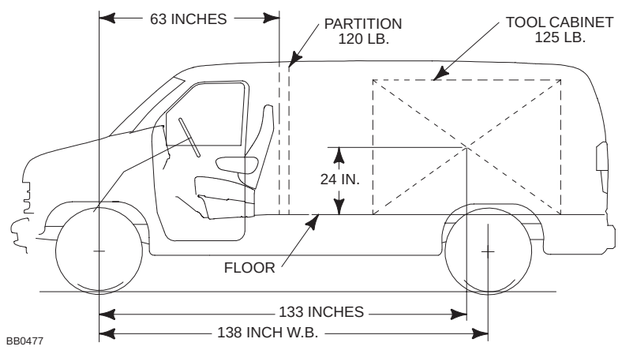
$$CG_h = \frac{260 + 1080 + \frac{400\ x\ 53.9}{113.9}}{3562}\ x\ 113.9 = 48.9 \text{ inches}$$

From table 1, page 48:
Upper Limit CG_v = 1.39 x 48.4 – 36.8 = 31.2 inches
Lower Limit CG_v = 1.39 x 48.4 – 51.7 = 16.3 inches
The 25.6 inches calculated is within the range given so this vehicle is acceptable from a compliance to FMVSS and CMVSS 105 standpoint.

Sample (2) Econoline Under 8000 lb GVWR 138 inch WB

Altering a completed E-150 vehicle with the addition of a permanently attached tool box and partition can be handled as follows:

E–150 ALTERED COMPLETED VEHICLE ADD TOOL CABINET AND A PARTITION



The vertical distance above the floor is

$$V = \frac{Wt\ 1\ (CG_{1V})\ +\ Wt\ 2\ (CG_{2V})}{Wt\ 1\ +\ Wt\ 2}$$

$$V = \frac{125(24)\ +\ 100(25)}{125\ +\ 100}$$

= 24.4 inches

The longitudinal distance aft of the front axle is

$$L = \frac{Wt\ 1\ (CG_{1h})\ +\ Wt\ 2\ (CG_{2h})}{Wt\ 1\ +\ Wt\ 2}$$

$$= \frac{125(133)\ +\ 100(63)}{125\ +\ 100}$$

= 101.9 inches

Using equation for Min L from Table A on page 45:

Min L = .23 (138) + 21.4 + .72 (24.4)

Min L = 70.7 inches

Since 101.9 is greater than 70.7, this meets the L_{MIN} criteria.

If the vehicle curb weight + 400 lb. for passengers (before alteration) is: front = 2825 lb; rear = 1888 lb; and, total = 4713 lb, adding the alteration weight of 225 lb which is distributed as follows:

101.9 (225) — Rear Axle Reaction (138) = 0
Rear Axle Reaction = 166 lb
Conversely the Front Axle Reaction = 225 lb – 166 lb = 59 lb

W_{rul} = 1888 lb + 166 lb = 2054 lb

W_{rul} = 4713 lb + 225 lb = 4938 lb

Max W_{rul} = (.58) (4938) = 2864 lb

So a W_{rul} of 2054 lb is less than the max. $W_{rul,}$ therefore, meets the criteria specified for compliance with FMVSS and CMVSS 105.

If the add-on weight of the SUB is forward of the centerline of the rear axle while conforming to GAWR, GVWR, ARC, and for pickup box removal vehicles min./max. SUB weight restrictions (Table A page 194) are conformed to, then there are no FMVSS and CMVSS 105 issues.

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TABLE 1

CG_V = Vertical distance from the ground to the completed vehicle center of gravity (inch).
GVWR < 8000 lb Use equation A & B, page 45

Model	WB (in.)	Equation for CGv Range	
		Upper Limit	Lower Limit
Ranger 4x2 GVWR ≤ 4580 lb	112	CG_V = 1.39 X CG_h – 34.8	1.39 X CG_h – 49.0
	118	CG_V = 1.39 X CG_h – 36.8	1.39 X CG_h – 51.7
	126	CG_V = 1.39 X CG_h – 40.3	1.39 X CG_h – 56.7
Ranger 4x2 GVWR ≥ 4580 lb	112	CG_V = 1.39 X CG_h – 36.0	1.39 X CG_h – 42.0
	118	CG_V = 1.39 X CG_h – 38.5	1.39 X CG_h – 44.6
	126	CGv = 1.39 X CG_h – 45.5	1.39 X CG_h – 48.6
Ranger 4x4 GVWR ≥ 4580 lb	112	CG_V = 1.39 X CG_h – 32.8	1.39 X CG_h – 38.4
	118	CG_V = 1.39 X CG_h – 34.7	1.39 X CG_h – 40.5
	126	CG_V = 1.39 X CG_h – 38.0	1.39 X CG_h – 44.4

Model	WB (in.)	Equation for CGv Range	
		Upper Limit	Lower Limit
E-150	138	CG_V = 1.39 X CG_h – 46.9	1.39 X CG_h – 58.7
E-250 7900 lb GVWR	138	CG_V = 1.39 X CG_h – 47.1	1.39 X CG_h – 59.0

GVWR ≥ 8000 lb Use equation C & D, page 45
Place the CG_h of the vehicle (from equation D) into the appropriate equations below to determine the allowable range of the CG_V. If the actual CG_V (from equation C) is within the range calculated, the center of gravity location is acceptable.

Model	WB (in.)	Equation for CGv Range	
		Upper Limit	Lower Limit
E-250 7900 lb GVWR	138	CG_V = 1.27 X CG_h – 59.0	1.27 X CG_h – 77.5
E-350 (SRW) ≤ 9600 lb GVWR	138	CG_V = 1.27 X CG_h – 60.0	1.27 X CG_h – 80.0
	158	CG_V = 1.27 X CG_h – 69.5	1.27 X CG_h – 90.7

TABLE 2
CG_{VC} = Verticle distance ground to chassis CG
(Dimensions are in inches)

Super Duty F-250/350 (4X2) SRW > 8500 lb GVWR	= 30.0
Super Duty F-250/350 (4X4) SRW > 8500 lb GVWR	= 31.0
Super Duty F-350 (4X2) DRW	= 30.0
Super Duty F-350 (4X4) DRW	= 31.0
Super Duty F-450/550 (4X2 & 4X4) DRW	= 35.0
E-150 & E-250 Van < 8000 lb GVWR	= 28.5
E-250/350 SRW Van or Wagon > 8000 lb GVWR	= 32.0
E-250/E-350 Super Duty Cutaway	= 28.0
E-450 Super Duty Cutaway	= 26.5
E-250 SRW Stripped Chassis	= 25.0
E-350 Stripped Chassis	= 26.5

TABLE 3
CG_{hp} = Horizontal distance from front wheel ℄ to Passenger Load.
(Dimensions are in inches)

All Rangers	53.9
All Super Duty F-Series	61.2
All Econoline †	48.5

† Except Stripped Chassis where the distance from the ℄ of the front axle to the H-point of the driver must be measured.

TABLE 4
CG_{hl} = Horizontal distance from front axle cargo CG:

Model	WB (in)	CG_{hl} (in) †
Super Duty F-Series:		
-Regular Cab	137.0	132
-Regular Cab	140.8	134
-Regular Cab	164.8	146
-Regular Cab	200.8	164
-SuperCab	158.0	153
-SuperCab	161.8	155
-Crew Cab	172.4	165
-Crew Cab	176.2	167
Econoline:		
-Regular Van	138	116
†Extended Van or Extended Wagon	138	126
†RV Cutaway (SRW)	138	121
(DRW)	138	127
(DRW)	158	138
(DRW)	176	153
†Comm. Cutaway (SRW)	138	121
with Cab/Box Partition	158	134
without Cab/Box Partition	138	127
	158	143
	176	160

†If CG_{hl} is not given in the table or if the location of your cargo is not in the normal cargo area, then your CG_{hl} may be estimated as the distance from the ℄ of the front wheel to the horizontal midpoint of the cargo area.